FLOOR PROCESSING MACHINE

Field of the Invention

The present invention relates to a processing or finishing machine for grinding, polishing and/or machining of hard floors, such as terrazzo, marble, stone, concrete floors and the like, according to the preamble to claim 1.

Background Art

Machines for grinding hard floors, such as terrazzo, marble, stone, concrete floors and the like, are known and marketed by, inter alia, the applicant. Prior-art grinding machines for this purpose usually consist of a rotatably mounted solar disc which is driven by an electric motor and on which a plurality of, usually three to six, planetary disc are arranged. On each of the planetary discs there are arranged one or more holding plates, which each support one or more grinding elements, polishing elements and/or cutting tools. The grinding machine usually has a handle bar, adjacent to which actuating means are positioned; wheels, which constitute supports and facilitate the handling of the grinding machine, and optionally a water tank to allow supply of water to the grinding spindle. The grinding machine is designed, in grinding, to be propelled in front of and by a walking operator. A drawback of this type of finishing machine is that it has a low capacity, which is disadvantageous when grinding large surfaces.

US 6,419,565 B2 discloses how a prior-art floor finishing machine for grinding of wooden floors can be connected to a driven rider trailer, so that the operator, during grinding, can ride behind the finishing machine and, thus, does not have to walk. However, also this grinding machine suffers from the drawback of low capacity.

US 5,070,656 discloses how a finishing unit can be placed on the lifting unit of a fork lift truck, so that the operator, during grinding, can propel the fork lift truck and, thus, does not have to walk. Also this finishing unit suffers, however, from the drawback of low capacity.

A similar arrangement is disclosed in JP-2000-317803. A problem of this finishing unit is that the greater the capacity of the finishing unit, the more difficult the operating and transporting of the same.

US 5,605,493 discloses a machine for wet grinding of stone floors, in which a driving source, a working head for grinding and a collector are arranged on a frame. Also this machine has a low capacity and requires the operator to walk behind the machine for steering the same.

WO 92/02334 discloses a mobile grinding machine for grinding of concrete floors according to the preamble to claim 1. Also this mobile grinding machine suffers from problems with regard to capacity.

There is thus a need for an improved finishing machine, which has a high capacity, a high degree of efficiency, good operability, good transportability and which can be manufactured at reasonable cost.

Summary of the Invention

An object of the present invention is to provide a finishing machine which wholly or partly eliminates the problems of prior-art technique.

The object is achieved wholly or partly by a finishing machine according to the independent claim. Embodiments are defined by the dependent claims and by the following description.

Thus, a finishing machine is provided for finishing a work surface which consists of a floor of terrazzo, marble, stone, concrete or the like, the finishing machine comprising at least two finishing units which are supported by the frame of the finishing machine and which

are arranged for grinding, polishing and/or machining of the work surface, each finishing unit comprising a motor and a rotatably mounted working disc driven by the motor. The finishing units are individually tiltable relative to the frame about respective axes that are substantially parallel to the work surface.

By the finishing units being tiltable relative to the frame, the finishing machine can be designed so that it can finish a wide trace and thus has great capacity while at the same time the machine can be made sufficiently narrow to be transported on a lorry or trailer, and to be able to pass through gates etc. to the area which is to be finished. Another advantage is that standard-type finishing units can be used, so that no specially made finishing units have to be provided, which contributes to reducing the cost of the finishing machine.

A finishing machine with the above features also enables easy access to the working disc for service and for exchange of finishing elements. This is advantageous if a finishing machine with high capacity is to be provided, since such a finishing machine can be too heavy to allow it to be tilted for access to the working disc. Moreover the operator does not have to perform the uncomfortable or even dangerous working operations that are involved in maintenance of the finishing unit without being able to see it distinctly.

In one embodiment, the finishing unit is connected to the frame by a holder, which is hingedly connected to the frame, so that the finishing unit is pivotable relative to the frame.

In one embodiment, a means is arranged for adjusting the angle of the holder relative to the frame.

In one embodiment, the finishing unit is connected to the frame by a holder, which is turnably connected to the finishing unit, so that the finishing unit is tiltable relative to the frame.

In one embodiment, a means is arranged for adjusting the angle of the holder relative to the finishing unit.

In one embodiment, a front part of the frame, seen in the main travelling direction of the finishing machine, projects in front of a front pair of wheels of the finishing machine to form a supporting frame on which the finishing units are mounted. This arrangement results in improved access to corners.

In one embodiment, a part of the first finishing unit, which is positioned furthest away from a centre axis located in the longitudinal direction of the finishing machine, is positioned further away from the centre axis than parts of a second and a third finishing unit, which parts are located next to the centre axis. This provides an overlap between the area that is finished by the first unit and the respective areas that are finished by the third and second units.

In one embodiment, the first finishing unit is tiltable about an axis substantially perpendicular to the centre axis of the finishing machine, and the second and third finishing units are tiltable about respective axes parallel to centre axis of the finishing machine. It is thus possible to make the machine relatively narrow and, consequently, easy to transport when the finishing units are raised.

In an alternative embodiment, the first finishing unit is tiltable about an axis which is substantially perpendicular to the centre axis of the finishing machine, wherein second and third finishing units are tiltable about a second and a third axis respectively, and wherein said second and third axes, or their extension, form an acute angle to each other.

In one embodiment, each of said finishing units is arranged to abut against the work surface by a force which essentially equals the weight of the finishing unit.

In one embodiment, each of said finishing units, when engaging the work surface, is displaceable relative to the frame in a direction which is substantially perpendicular to the work surface.

The finishing machine may comprise an internal combustion engine, which via a generator and associated frequency converters supplies power to said finishing units and at least one propelling unit. Such a finishing machine can be given very high capacity, combined with small emissions and an even sound level, regardless of load.

In one embodiment, each of said frequency converters is controllable by a control unit, which control unit is capable of collecting control data from a manually actuated control means, a radio control unit or an autonomous navigation unit. This arrangement thus allows a great freedom of choice regarding which control mechanism is selected for the finishing machine.

In one embodiment, said propelling unit comprises two electric motors arranged to drive a drive wheel each, each of said electric motors being individually controllable by an associated frequency converter. Such an arrangement can be given excellent manoeuvrability combined with a great freedom of choice regarding which control mechanism is selected for the finishing machine.

In one embodiment, the finishing machine comprises at least one pivot wheel which together with said drive wheel forms a supporting surface for the finishing machine. Such a finishing machine can be given excellent steerability and a great freedom of choice regarding the control mechanism.

In one embodiment, an image-generating device is arranged to allow inspection in real time of the finished work surface in connection with the work surface being finished by the finishing machine. This allows inspection of the finishing result in real time.

In one embodiment, the finishing machine comprises a driver's seat having an operator's seat and an actuator. Such a finishing machine is thus ridable, which reduces the physical efforts that are associated with finishing.

Examples of embodiments will now be described in more detail with reference to the accompanying drawings.

Brief Description of the Drawings

Fig. 1 is a schematic perspective view of a finishing machine in one embodiment of the invention.

Fig. 2 is a schematic side view of the finishing machine in Fig. 1.

Fig. 3 is a schematic perspective view of the finishing machine in Fig. 1, the finishing units of the machine being in a transport position.

Fig. 4 is a schematic perspective view of the finishing machine in Fig. 1, the finishing units of the machine being in a service position.

Figs 5a and 5b are schematic side views of a working head and its attachment to the frame.

Fig. 6 is a schematic top plan view of the finishing machine in Fig. 1.

Fig. 7 illustrates an example of a working head seen from below.

Figs 8a-8c illustrate an embodiment of a supporting frame, on which a plurality of finishing units are mounted.

Fig. 9 illustrates schematically functional components of a finishing machine in one embodiment.

Fig. 10 shows an enlargement of the area B in Fig. 8a.

Description of Embodiments

Fig. 1 shows a riding finishing machine 1, which comprises a frame 14 (Fig. 2), on which a set of wheels 2a, 2b, 2c, 2d is arranged, so that the finishing machine can travel on a base 20 (Fig. 2).

The frame 14 of the finishing machine is arranged to support essentially all parts of the finishing machine. The frame can be a substantially rigid frame element or bottom plate, or be hinged, for the purpose of, for instance, facilitating manoeuvring.

The set of wheels 2a, 2b, 2c, 2d serves to provide a two-dimensional supporting surface for the finishing machine 1 on the base 20 and can be designed in various ways, depending on which driving properties are required for the machine.

The frame also supports an engine 6. The engine dimension and the choice of compulsion force/fuel are determined based on the capacity required by the finishing machine 1. In one embodiment of the finishing machine 1, the engine can be a gas-driven or diesel-driven internal combustion engine. The engine 6 is suitably arranged so as to operate at a substantially constant speed and constant load, thus reducing the emissions from the engine. In one embodiment, the engine is arranged to drive a generator 7.

By letting the engine 6 drive a generator 7, force is generated both for propelling the finishing machine 1 and for driving the finishing units and auxiliary equipment, such as a dust collector.

A steering device (not shown) can be arranged to allow steering of the movement of the finishing machine 1 over the work surface 20. The steering device can be actuatable in prior-art manner.

As a first example, the finishing machine 1 can have a driver's seat 12, comprising a seat 11 and a joystick 10 which is arranged adjacent to the driver's seat 12 and which actuates the steering device (not shown).

As a second example, the steering device (not shown) can be actuatable at a distance from the actual finishing machine, for example by radio control (not shown).

As a third example, the steering device (not shown) can be actuatable in response to instructions from a

substantially autonomous unit, such as a robot control device (not shown), which is programmable to control the machine in a predetermined manner, which possibly may have a function avoiding obstacles. Also other prior-art steering devices are conceivable.

The finishing machine 1 can have a plurality of, for instance three, finishing units, which can be of prior-art type. Each finishing unit comprises a motor 4a, 4b, 4c and a working head 3a, 3b, 3c driven by the motor. In one embodiment, such a working unit can be of the type that appears in the finishing machine propelled by an operator, as shown in, for example, WO02/062524A1. Such a working head 3a, 3b, 3c may comprise two or more, preferably four or six, rotatably mounted and driven working discs 41 arranged on planetary discs (Fig. 7), each working disc supporting one or more grinding elements 42 (Fig. 7) or cutting elements. The working discs 41 can in turn be rotatably arranged on a supporting plate 40 which has the form of a solar disc, which in turn can be rotatably mounted. The supporting plate may comprise a planetary gear arrangement which is arranged so that the supporting plate 40, when made to rotate by the motor 4a, 4b, 4c, in turn makes the working discs rotate, or vice versa. The rotation is schematically shown by the arrows in Fig. 7, but it will be appreciated that the rotary directions may vary depending on the design of the planetary gear. In one embodiment, the number of planetary discs is even, preferably four or six, arranged so that two adjoining planetary discs rotate in opposite directions. The finishing elements 42 are usually exchangeable.

As is evident from Fig. 1 compared with Fig. 3, the finishing units can be vertically displaceable between a working position (Fig. 1) and a transport position (Fig. 3).

In the working position, the finishing units 3a, 3b, 3c; 4a, 4b, 4c are arranged so that the working discs 41

rotate in a plane which is substantially parallel to the work surface 20, the finishing elements 42 (Fig. 7) being in finishing engagement with the work surface 20.

Fig. 3 shows the finishing units in the transport position, i.e. at a distance from the work surface 20, thus facilitating movement of the machine over surfaces that are not to be finished.

As is evident from Fig. 4, the finishing units can be rotatably, pivotally and/or tiltably mounted, for instance tiltable about a substantially horizontal axis parallel to the work surface 20 between a working position or transport position and a service position, where the working discs 41 are positioned at an angle relative to the work surface, thereby facilitating access to them for cleaning or exchange of consumption parts, such as working discs 41 and/or finishing elements 42. In one embodiment, the finishing units can be arranged to be rotated, pivoted and/or tilted to such an extent that the working discs 41 will be positioned in a substantially vertical or near vertical state, for instance so that the working discs make an angle of at least 45 degrees to the work surface 20, preferably 70-90 degrees.

Figs 5a and 5b illustrate schematically how a finishing unit 3, 4 can be arranged on a holder 5 projecting from the frame 14. The holder 5 can be pivotally arranged relative to the frame about a first hinge 33, the degree of pivoting being actuatable by a first actuating means 31. Correspondingly, the finishing unit 3, 4 can be rotatably or tiltably arranged relative to the holder 5 about a second hinge 34, the degree of rotation being actuatable by a second actuating means 32. The first and second hinges 33, 34 can be substantially parallel to the work surface 20.

The actuating means 31, 32 can be any actuating means for providing a linear motion. Examples of such actuating means can be hydraulic or pneumatic pistons, rack and pinion drives etc. Other actuating means for

providing an angular motion or tilting motion of the grinding head relative to the frame can also be used.

The actuating means 31, 32 and the hinge arrangement of the finishing unit 3, 4 make it possible to adjust the finishing unit to the frame, for instance between a transport position (shown in Fig. 3 only), a service position (Fig. 4, Fig. 5b) and a working position (Fig. 1, Fig. 5a). It is also possible to use the actuating means 31, 32 and the hinge arrangement of the finishing unit 3, 4 to exactly adjust the working position of the finishing units 3, 4 in connection with finishing.

The actuating means 31, 32 can be controllable from the driver's seat of the finishing machine 1, by radio control or by the autonomous unit, depending on which control device has been selected.

In one embodiment, the finishing machine may have a length of about 2-2.7 m between front and rear wheel axles, a wheel diameter of the front wheels amounting to about 530 mm and a total length from the rear part of the frame to the front part of the front working head amounting to abut 3-3.7 m. Such a machine can be provided with three working heads and thus be given a substantially higher capacity than machines that are currently available on the market.

It will be appreciated that the above-described arrangement of the finishing unit is not limited to the described type of finishing machine.

Fig. 6 is a schematic top plan view of a finishing machine 1 according to an embodiment. Fig. 6 shows more distinctly the position of the working heads over the work surface of the finishing machine. In this embodiment, a first finishing unit 3a, 4a is positioned essentially at the front of the finishing machine, in its main travelling direction. The centre of the first finishing unit 3a, 4a essentially coincides with a central longitudinal symmetry axis S of the frame 14 (Fig. 6).

Second 3b, 4b and third 3b, 4b finishing units are arranged essentially symmetrically on the respective sides of the symmetry axis S (Fig. 6), behind the first finishing unit 3a, 4a in the main travelling direction of the finishing machine 1. In one embodiment, the second and third finishing units are arranged so that a part of the second 3b and third 3c working heads, respectively, which is closest to the symmetry axis S, is positioned at a shorter distance from the symmetry axis S than a part of the first working head 3a which is positioned furthest away from the symmetry axis S. This arrangement makes it possible for the finishing machine to grind, polish and/or machine a relatively wide area seen transversely to the main travelling direction of the finishing machine, without significantly deteriorating the access to surfaces in corners.

Figs 8a-8c illustrate an embodiment of a supporting frame on which three finishing units are arranged in one embodiment of the invention.

Fig. 8a shows the finishing units of the finishing machine in a working position, i.e. in a position when they are in grinding, polishing and/or machining engagement with a floor surface. The supporting frame 101 shown in Fig. 8a is designed to wholly or partly project in front of the front drive wheels 2a, 2d, 201 of the finishing machine. The supporting frame 101 consists in this embodiment of an arrangement of beams 102, 103, which tapers forwardly in the travelling direction of the finishing machine. A first finishing unit 3a, 4a is mounted at the point of intersection of the beams. This first finishing unit is tiltable about an axis which is substantially perpendicular to the longitudinal axis S of the finishing machine (Fig. 6). Second and third finishing units are mounted on the beams 102, 103 and are thus tiltable about the respective axes which make an angle of about 45° to the longitudinal direction S of the finishing machine (Fig. 6). It will be appreciated that also

other angles relative to the longitudinal direction S are conceivable.

In an alternative embodiment, the supporting frame 101 can be narrower than the remaining part of the frame 14, 100.

The finishing units 3a, 4a; 3b, 4b; 3c, 4c are connected to the supporting frame 101 by the respective holders 5. Actuating means 31, in the form of hydraulic cylinders, are arranged for setting the angle of the holder 5 relative to the supporting frame 101 and, thus, actuating the tilting of the finishing units.

Fig. 8b shows how the finishing units of the finishing machine shown in Fig. 8a have been tilted to a service position, where the solar disc 40 and working discs 41 of the finishing units are accessible for service, such as exchange of grinding discs 42 (Fig. 7).

Fig. 8c shows how the finishing units of the finishing machine shown in Fig. 8a have been tilted to a transport position, so that the total length and width of the finishing machine have been substantially reduced relative to the working position shown in Fig. 8a.

In one embodiment, the supporting frame 101 can be made vertically pivotable relative to the remaining part of the frame 14, 100. For instance, a hinge can be arranged parallel to the crossbar 104 (Fig. 8a).

In one embodiment, the finishing units are arranged so that their working areas, as the finishing machine moves, overlap each other, i.e. so that a part of a first finishing unit 3a, 4a which is positioned furthest away from a centre axis S, located in the longitudinal direction of the finishing machine, is positioned further away from the centre axis S than the respective parts, located closest to the centre axis S, of a second 3b, 4b, and third 3c, 4c finishing unit, respectively.

In one embodiment, the first finishing unit 3a, 4a is tiltable about an axis which is substantially perpendicular to the centre axis S of the finishing machine,

and the second and third finishing units 3b, 4b; 3c, 4c, are tiltable about the respective axes which are parallel to the centre axis S of the finishing machine.

In another embodiment, the first finishing unit 3a, 4a is tiltable about an axis substantially perpendicular to the centre axis S of the finishing machine, and the second and third finishing units 3b, 4b; 3c, 4c are tiltable about second and third axes, respectively, and said second and third axes, or their extension, form an acute angle to each other. For instance, the second and third axes, respectively, can be parallel to the beams 102, 103 shown in Figs 8a-8c.

A finishing machine as described above can be designed for efficient finishing of very large surfaces. It will be appreciated that when finishing large surfaces, such as factory, warehouse or store floors, the finishing machine is required to have a high capacity.

In the following, it will be described how a finishing machine with high capacity and high efficiency can be provided.

Fig. 9 illustrates schematically functional components of a finishing machine 1 in one embodiment. In Fig. 9, unbroken lines between components indicate transmission of power and dashed lines indicate transfer of control and/or sensor data.

The finishing machine 1 is mounted on a frame 100, which is movable over a work surface (not shown) by means of a front set of wheels 201 consisting of drive wheels, and a rear set of wheels 202 consisting of pivot wheels. The drive wheels 101 are arranged to be driven individually by perspective drive motors 200. The pivot wheels are turnable in a plane parallel to the work surface and are, in one embodiment, idle, and their main function is to form, together with the drive wheels 201, a supporting surface for the finishing machine.

On a front part 101 of the frame, a plurality of, preferably three, finishing units 300 are arranged, for example in an arrangement as described above.

An internal combustion engine 400, driven by diesel, gas, liquified petroleum gas, petrol or the like, is arranged to constitute the power source of the finishing machine. A torque is transmitted from the internal combustion engine 4 to a generator 500 for generating electric current. A power distributor 600 is used to distribute power to the other units in the finishing machine; frequency converters 800a, 800b, drive motors 200, finishing units 300, control unit 700, dust collector, low-voltage section 650 etc.

By using an internal combustion engine connected to a generator, it is possible to provide a finishing machine which can operate for a long period without charge or refuelling. Moreover the internal combustion engine can operate at a constant speed, which is advantageous in terms of fuel economy, sound level and wear.

The frequency converters 800a, 800b are arranged to individually control the speed of the drive motors 200 and the finishing units 300. This type of control makes it possible to individually control the rotary speed of each of the drive wheels 200, thus allowing electronic control of the speed as well as the direction of the finishing machine, without a mechanical control device. By the drive wheels being controlled electronically according to the fly-by-wire principle, it is possible to achieve great flexibility in the choice of control mechanism for the finishing machine.

The drive motors can be of the asynchronous type, which is advantageous especially in terms of cost.

In one embodiment, the finishing machine is controlled by a joystick or equivalent control means 701 positioned in the finishing machine.

In another embodiment, the finishing machine is controlled by a remote control 702, which transfers control

signals to the control unit 700 by cable, radio communication or the like.

In yet another embodiment, the finishing machine is controlled by means of an autonomously or substantially autonomously navigation system 703. Such navigation systems can use one or more set-out reference points, artificial vision, control by laser beams or induction coils, obstacle-avoiding devices based on, for instance, optical sensors or ultrasonic detection.

In one embodiment, a device 704 for inspection of the finishing result, for instance a camera, can be arranged behind the finishing units 300 in the travelling direction. An output from the device 704 can be presented on a display 705 adjacent to the driver's seat or in a unit by which the finishing machine is remote controlled. Such a device 704 can possibly be combined with a light source.

It will be appreciated that the finishing machine described with reference to Fig. 9 can be designed with other types and arrangements of finishing units and mounting of the same than shown in Figs 1-8.

Fig. 10 illustrates a detail of the area 'B' marked in Fig. 8a. Fig. 10 shows parts of the finishing unit 3a, 4a and of the attachment of the holder 5 to the finishing unit. The attachment of the holder 5 to the finishing unit consists of a pin 34 which is arranged in a slot 35 which is formed in the holder 5 and is substantially vertical in the working position so that the pin 34 is movable in the slot 35. This movability allows displacement of the finishing unit relative to the frame 100, so that the finishing unit is essentially freely mounted relative to the frame. With this arrangement, each of the finishing units 3a, 4a; 3b, 4b; 3c, 4c, 300 can be arranged to abut against the work surface 20 by a force which essentially equals the weight of the finishing unit (i.e. mass x acceleration of gravity).

Thus, each of said working units 3a, 4a; 3b, 4b; 3c, 4c, 300 can, when engaging the work surface 20, be displaceable relative to the frame 14 in a direction substantially perpendicular to the work surface 20. A person skilled in the art realises that this displaceability or free mounting can also be provided in other ways.